From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : v
Paragraph : Paragraph 2 last sentence
Comment : The SPH approach used by ARA in the analysis for the fuel dispersion following the impact is relatively untried and is not well validated through experiments. Could the researchers clarify what level of confidence they have in the accuracy of predicting fuel dispersion and how this might have influenced the subsequent fire analysis?
Arup□s experience in the modelling fluids suggests fuel dispersion an exceedingly difficult thing to predict and an area where any analysis needs to be considered carefully and supported by laboratory based experimental validation. Given the importance of this study, we believe some testing should have been carried out to confirm the analytical models used prior to assuming dispersal patterns are adequate or correct.

Comment Reason : The report does not adequately explain the limitations of the technical approach taken.

Revision Suggestion : Clarification of the level of confidence or uncertainty in these results.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : x1vi
Paragraph : E.2.1 Global Models of Towers
Comment : Was any attempt made to correlate the total weight of the building with the debris removed?
Comment Reason : While accepting that this would have been an approximation, the data could have been used to estimate the overall loads on the building at the time of impact. This would have given greater confidence in the levels of reserve available at the time of the impact.

Revision Suggestion : Compare amount of debris known to have been removed during the clear operation with the mass used in the global analysis models.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1iv and 1v
Paragraph : Demand Capacity Ratios (DCRs) Paragraph 2
Comment : The baseline analysis examines the DCRs for design loads on the complete tower (figures E-5 and E6). Given that the actual building would typically see less load than this, has any estimate of the actual DCRs for the building in its Sept 11 2001 states? Given that the corners, which general had DCRs in excess of 1, were shown to buckle during the building collapses it might be useful quantify the reserve capacity in the column by checking the DCRs for actual loads on the day for pre and (immediately) post impact states and check these were less than unity.
Comment Reason : Looking a actual DCR□s would provide better estimate of the condition of the building post impact, a main objective of project 2.

Revision Suggestion : Re- analyse using actual loads

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1viii
Paragraph : Section E.5.1 Development of Tower Impact Models
Comment : We believe the global model (of the type shown in figure E-11) had no initial stress in the column and that this was justified by some simple tests using column models. The global model also ignored the overall response of the structure, presumably on the basis that the duration of the impact event was significantly less than the natural period of the building. Could NIST clarify how any P-Δ effects (as a result of the swaying) in the post impact condition were accounted for? From the work reported, post impact P-Δ effects before the fire took hold seem to have been neglected but there is no justification is given. Could P-Δ effects as a result of the significant swaying of the building after impact have influenced the severity of the column damage?
Comment Reason : Inadequancy in the analysis

Revision Suggestion : Justification for neglecting this or re-analysis taking load re-distribution and P-Δ effects into account.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xv
Paragraph : Section E.5.2 Development of Aircraft Impact Models, Paragraph 1
Comment : The report is vague as to exact details of the aircraft data used □ much of the aircraft model seems to have been developed without detailed engineering drawings or more than some cursory measurements. Whilst it might be argued that the strength of the fuselage is not that significant, the 1-2B report (page 368, section 10.2, last paragraph) notes, and we agree, that the strength of some of the denser elements are significant. Recognising Boeing□s desire to retain proprietary information, have Boeing engineers scrutinised the component masses, thicknesses and dimensions used in these models? Have other LS-Dyna experts checked the aircraft impact model in the same way that SOM checked the building models?
Comment Reason : The limited data used to develop the aircraft models may not have been adequately bounded by the uncertainty analysis. Given that the structure of a B767 aircraft is known it seems sensible to check this data where possible.

Revision Suggestion : Clarification regarding the level of checking used in developing the aircraft data.

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxviii
Paragraph : Section E7.1 WTC1 Base Case Analysis, Paragraph 2
Comment : As noted previously (see comments on pg lxv) the aircraft models appears to be based on relatively sparse engineering data □ this is surprising, given that B767 design data exists and any inaccuracies in the aircraft model would increase the level of uncertainty in the result. Our concern relates to the limited details in the report about the undercarriage structure and assembly and wing supports (typical weighing 10-12tons)?
Comment Reason : These would have been critical elements determining the state of the core.

Revision Suggestion : Clarify what detailed information was used to model this component and how was this data collected?

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxixx
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section External Wall Damage, Paragraph 2
Comment : How were gravity and aero-elastic forces on the wing applied? It seems the wing deflections in flight were accounted for but the report if unclear how this was done?
Comment Reason : Limited information in report

Revision Suggestion : Clarification

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxxv
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 1,
Comment : Limited experimental validation work that has been carried out using this method for fuel dispersion. As the analysis ignored the containing effect of the windows, wetting and the multi phase nature of the fuel combustion process during impact, the actual results are at best subjective.
Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : ci
Paragraph : E.7.2 WTC2 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 2,
Comment : See previous comments on (pg lxxxv above) regarding the use of SPH to model fuel dispersal.
(The report notes that the work could not reconcile the fuel getting through 200/300 sides.)

Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : cix
Paragraph : Section E.7.7
Comment : Detailed comparison of damage on □back□ walls (ie south wall of WTC1 and north face of WTC2) between observables and analysis are not shown. The reports notes later that correlation between the impacts and analyses are poor on these faces.
Comment Reason : Limited information in report

Revision Suggestion : Clarification of impact damage estimates

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 6
Paragraph : Section 1.3 Aircraft Impact Damage Analysis Bullet 2
Comment : The sensitivity analysis seems to neglect much of the uncertainty in the aircraft data used in the model. (see our previous comments relating to Page lxxvii)
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 93
Paragraph : Section5.1 Introduction
Comment : We have often found in large civil and building engineering models, used to explicitly simulate impact and seismic events in real time, variation of results between LS-Dyna analyses using 32 bit and the higher precision 64 bit software. We have occasionally seen significant rounding errors on 32 bit computer software when representing physically large dimensions where relatively small displacements in elements trigger failures. Were any of the results models checked using 64 bit precision to test the accuracy of results? The limitations on models size noted in the report are related to 32 bit operating systems. If the impact models had been run on 64 bit operating systems we believe the limitations on model size would have been avoided.

Comment Reason : One dimensionally large model the accuracy of the analysis results needs to be checked using double precision.
The original NIST objective of using state of the art analyses for the Project 2 seems to have been missed. The limitation on model size could have been avoided by using computers with 64 bit operating systems.

Revision Suggestion : Re-analysis of a few of the larger models using 64 bit software.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 269
Paragraph : Section 7.10.1 , Comparison with Observables on WTC1 Landing gear Trajectory
Comment : We accept that the trajectory calculations are difficult. Our calculations show this to be 120mph if no rolling occurred. Was there any evidence of rolling or ricocheting down the road?
Comment Reason : Limited information concerning the observables

Revision Suggestion : Comments regarding the processes used for recording debris data.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 281
Paragraph : Section 7.10.2, Comparison with Observables on WTC2, Engine Trajectory Comparison
Comment : Could the crash investigators tell whether this was a starboard or port engine?
Comment Reason : Limited information

Revision Suggestion : Clarifcation

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 289
Paragraph : Section 7.11.1 Comparison of External Wall Damage
Comment : See our previous comments about the modelling of fuel in the impact. Was any sensitivity study carried out using the SPHs to correlate this with fuel falling out of the building?
Comment Reason : Shortcoming in SPH method

Revision Suggestion : Clarification of limitations

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 11
Comment : Although conventional office buildings tend not to consider aircraft impact as a foreseeable hazard, nuclear facilities in the US and elsewhere do. The finding that an aircraft impact was considered at the time of the design of the WTC1 and 2 demonstrates that the possibility of impacts whether accidental or deliberate may need to be considered in some circumstances. Although current building codes don□t consider aircraft impact, it seems reasonable to assume that tall buildings or iconic architecture can be considered targets. The work carried out here should be developed to provide useful information to assist those wishing to design more robust buildings and other facilities irrespective of the building codes.
Comment Reason : General observation

Revision Suggestion : None

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 13
Comment : While generally in agreement that this could be the case, the SPH methodology used should be properly validated. Whether or not this has been done as part of this investigation is unclear.
Comment Reason : There is limited information in the reports to support this finding

Revision Suggestion : Clarification

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: j <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : j
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 300
Paragraph : Finding 18
Comment : The implication that the tower had sufficient reserve capacity because the natural frequency of the buildings post impact was similar to the undamaged state is incorrect. Because the construction of the towers is essentially tube like, the natural frequencies would not alter significantly even if the core was severely damaged. The following simple FE models demonstrate the insignificance of the core:
Simplistic Model Results

Results from five simple finite element models (of roughly the same geometric proportions as WTC1 and WTC2) demonstrate that a large hole in the side of a tube and the missing parts of the core do not significantly influence the natural frequency (see table 1).

Table 1 Variation of Natural Frequency (in Hz)

	Model 1	2	3	4	5
Bending	0.1653	0.1647	0.1643	0.1636	0.1637
Torsion	0.5981	0.5889	0.5981	0.5891	0.5889

Model 1

Tube & core
No holes Model 2

Large hole in side & no core. Model 3

No hole with core Model 4.

Large hole in side with core Model 5

Large hole in side and core missing at same level

Comment Reason : The stability of the towers immediately following the impact has not really been proven by the impact analysis. Simply taking the results of the impact damaged structure and loading it statically effectively ignores and damage that may have resulted due to swaying.

Revision Suggestion : Provide a more detailed analysis to take account of load path re-distribution in the core and the P-Δ effects of sway following the impact.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 300
Paragraph : Finding 19
Comment : The post impact state of the building has not been assessed rigorously. It would have been useful to see how the DCR□s based on estimated actual loads at the time had changed as a result of the impact damage and re-distributed loads paths □ we believe this was part of the scope of work was identified in the solicitation notice. This is discussed further in our comments on Report 1.
Comment Reason : The significance of load redistribution and effects of the sway have not been assessed using the global modes.

Revision Suggestion : Justifications for not examining load redistribution and sway effects need to be stated or further analysis is needed.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page xliv E-3
Paragraph : Summary of Findings bullet 4
Comment : The implication in Report 1-2A (see page 350) is that stairwell 3 was impassable. This paragraph suggests otherwise.

Comment Reason : .Contradiction with Report 1-2A (page 350)

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 41
Paragraph : Section 3.3 Paragraph 1
Comment : The number of core columns severed (9) and heavily damaged (1) do not tie up with the numbers identified in Report 1-2B, page 365 (5 failed, 4 heavy damaged)?
Comment Reason : Contradiction with other reports

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@NIST.GOV
Cc: dlowe@NIST.GOV
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 41
Paragraph : Section 3.3 second Section 3.3 second bullet
Comment : The numbers of core columns severed do not tie up with paragraph 1 on page 41. (or Report 1-2B page 365)
Comment Reason : Contradiction

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR 1
Page Number : Page 99
Paragraph : Section 6.6.4 sub section Core Framing, bullets 1-3
Comment : The analyses undertaken suggest that the condition of the core is key to identifying what margins existed immediately following the impact. The analysis does not seems to account for the swaying of the building following impact or examine the reserve or DCRs using estimated □actual□ loads on the building at the time of the impact. Similarly, as the analysis was essentially done statically no assessment seems to have been done to examine the way the loads re-distributed as columns were removed.
Comment Reason : While the response of the building is such that it will not influence the damage caused by the aircraft impact, the response will be significant in assessing the redistribution of loads or any additional damage induced by the building swaying. As the building was show to be unstable when gravity loads were applied in Case B severe impact damage, it would have been prudent to check the analysis model further by examining the effects of the sway and loads redistribution.

Revision Suggestion : We suggest sway and load redistribution are examined to demonstrate how much these potentially adverse effects influence the stability of the tower.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR 1
Page Number : Page 102
Paragraph : The Aircraft Structural Model
Comment : Our understanding is that no detailed information concerning the construction of the aircraft was released by Boeing. Was any attempt made by NIST to get Boeing to comment on the accuracy for the model? Significant portions of the aircraft appear to have been modelled using uncertain data.
Comment Reason : While it is likely for many parts the lack of precise details would not have been too significant, areas such as the wing spars and undercarriage support structure would be critical to assessing core column damage. Any analysis relies on the quality of input data to achieve It seems rather

Revision Suggestion :

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552051
Report Number : NCSTAR 1
Page Number : Page 203
Paragraph : Recommendation 3
Comment : While this is a reasonable suggestion, limiting sway deflections may have an adverse effect on energy absorption in impact events and almost certainly will have economic cost implications.
Comment Reason : Further work should be done to substantiate the cost benefits of this recommendation.

Revision Suggestion : Remove this recommendation until further research has been undertaken.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page lx
Paragraph : Table E-3

Comment : The impact speeds, lateral approach angles, vertical and lateral fuselage orientations in Table E-3 don□t tie up with those shown in Tables E-6 & E-7
Comment Reason : Apparent inconsistency between tables E-3, E-6 and E-7

Revision Suggestion : Clarification in the terms refined aircraft impact conditions and baseline terms.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page lx
Paragraph : Table E-3
Comment : The impact speeds, lateral approach angles, vertical and lateral fuselage orientations in Table E-3 don□t tie up with those shown in Tables E-6 & E-7
Comment Reason : Apparent inconsistency between tables E-3, E-6 and E-7

Revision Suggestion : Clarification in the terms refined aircraft impact conditions and baseline terms.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Pg 40
Paragraph : Section 3.2.1 Core Model Development
Comment : What allowances were made for elevator guide rails, cables, counterweights & cars? We believe only the structural steel is assumed in the model?
Comment Reason : No reference regarding how the elevator components were accounted for within the core.

Revision Suggestion : Check what these components were and, if necessary, re-examine to include additional structure in core model.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@NIST.GOV
Cc: dlowe@NIST.GOV
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : pg 52
Paragraph : Section 3.2.4 Interior Contents Model Development, third paragraph, last sentence.
Comment : Why were the superimposed dead loads also applied to columns - it is not usual to do so?
Comment Reason : This would potentially alter the results of the analysis as the effective mass of the columns would be increased.

Revision Suggestion : Check input data and if this statement is true re-run analyses without superimposed loads applied to the column.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup- London
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Pg 75
Paragraph : Section 4.3.1 Airframe Model Development
Comment : The main landing gear support structure and wheel well bulkhead are comparatively more substantial components than the fuselage. Was any attempt made to obtained detailed engineering design drawings of these components?
Comment Reason : The main landing gear support structure is a large component of strength comparable to or exceeding the wing box. Any breach made by the fuselage, nose landing gear and other components prior to the main landing gear components arriving at the external walls would have given the main landing gear support structure a relatively easy path through to the core. We argue that the input data used for the landing gear support structure components therefore would be critical to estimating the core damage. Because of the limited description of the model details and we believe the lack of engineering drawings made available by Boeing, we question the accuracy of the data used for these components.

Revision Suggestion : Clarify the data used for these components and check with Boeing for accuracy.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : 77
Paragraph : Table 4-4
Comment : We note the dry weight differences between GE CF6 and PWJT9D engines were not included in the respective WTC1 and WTC2 aircraft models □ were any runs done with the heavier GE CF6 engine weights?
Comment Reason : The engines were identified as potential damaging component so the correct (known) engine weights should have been used for each analysis.

Revision Suggestion : Justify that the heavier engine would not have altered the results of the analysis.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 89
Paragraph : General Comment on chapter 5
Comment : Was any attempt made to check the aircraft model by examining an impact with an immovable wall and comparing forces with methods based on rate of change of momentum models such as that developed by Riera as described in Chapter 10 page 367?
Comment Reason : No validation of the model is presented in the report to show how the overall forces generated by the model compare with other established methods.

Revision Suggestion : Demonstrate model robustness and overall forces are reasonable.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup- London
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : page 175
Paragraph : Chapter 8 Uncertainty analysis
Comment : The solicitation notice requested a formal, integrate approach was followed and include references outlining the procedure. The approach used here is considerably simpler. Why was the approach modified?
Comment Reason : The approach used falls short of the original ambitions required by NIST

Revision Suggestion : Clarification that the approach used in not as rigorous as originally intended.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 178
Paragraph : Table 8.1
Comment : The strength variations used seems rather low compared to the variations shown in Report 1-1, (page 67/68 of that report show measured/specified ratio in 10% - 30% range see Table 5.4 column data).

It is unclear whether the baseline values for material properties used were nominal or as per the values obtained from test data?

Why are the minimum values for horizontal and vertical locations the same as the baseline?

Exactly what is meant by varying strain rate effects by 1000%?

Comment Reason : Unclear

Revision Suggestion : Clarification needed

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 180
Paragraph : Section 8.2.1 Engine-Core Column Component Analysis, paragraph 1
Comment : The characterisation of the deformed columns takes no account of the building movements following the impact. While we agree gravity loads in the columns make little difference during the aircraft impact, were axial loads and P-Δ effects induced by the response of the building after the impact considered?
Comment Reason : We think this needs to be examined both at a component analysis and global level

Revision Suggestion : Demonstrate by analysis that the response of the building does not cause further damage or additional deformations.

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Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 183
Paragraph : Table 8-3
Comment : We question the large value used for the weight factors used in the wing parameters. Information from Boeing or detailed measurements could have been able to eliminate this uncertainty.
Comment Reason : Wing weight has a high response value in the uncertainty analysis.

Revision Suggestion : Examine why such a high variation was used.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 190
Paragraph : Figure 8-10 and also page 111 paragraph 1, sentence 4
Comment : Figure 8-10 would imply the engine trajectory was mainly horizontal on exit. Intuitively this feels incorrect.
Comment Reason : We question whether the workstations and the relatively lightweight concrete/steel composite floor would have been able to deflect a 4 ton engine travel at speed. Our own work examining penetrations of components on composite floor suggest that the contribution from the metal decking can significantly enhance the impact performance when compared with concrete slabs. (see Assessing perforation limits of steel section impacts on reinforced concrete slabs -Technical Note, The Structural Engineer, IStructE, December 2004). This is contrary to the findings page 111, first paragraph.

Revision Suggestion : Re-analysis using better representation of concrete/steel decking composite floor model.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 191
Paragraph : Section 8.3 Global Impact Analyses Parameter Selection, Paragraph 2

Comment : Although the report notes that the vertical impact position was significant in the subassembly analysis, the vertical impact location was not varied for the global analysis.
Comment Reason : It is difficult to understand the logic used not to investigate this further.

Revision Suggestion : Include vertical impact variations in the global analysis

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 192
Paragraph : Section 8.3 Global Impact Analyses Parameter Selection, Paragraph 1
Comment : The validity of the statement concerning the coupling effect of increasing strength and ductility increasing energy absorption is questioned.
Comment Reason : In conventional steels, higher yield strength only marginally increases energy absorption as the ductility of higher yield steels tends to decrease.

Revision Suggestion : Clarify by revising paragraph 1

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From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 195
Paragraph : 9.2 Assumptions and Limitations Paragraph 1
Comment : Please see our comments on Nist Report NIST NCSTRA 1-2, Page 93, Section 5.1 Introduction concerning limitations.
Comment Reason : As per page 93

Revision Suggestion : Re-assess the models using 64 bit precision.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 195
Paragraph : 9.2 Assumptions and Limitations Paragraph 1

Comment : Please see our comments on Nist Report NIST NCSTRA 1-2, Page 93, Section 5.1 Introduction concerning limitations.
Comment Reason : As per page 93

Revision Suggestion : Re-assess the models using 64 bit precision.

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From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 196
Paragraph : 9.2 Assumptions and Limitations second Paragraph (first bullet)
Comment : What effect would the window weight have if it had been included in the external columns?
Comment Reason : The additional mass of windows on the external columns would have altered the response and deformations of the columns.

Revision Suggestion : Justification for leaving the mass of the windows out of the impact models. Justification for not including them in the impact models to show containment of fuel.

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : 0+44 077552195
Report Number : NCSTAR1-2B
Page Number : Page 206
Paragraph : Figure 9-7b
Comment : A scale on this figure would be useful?
Comment Reason : The figure is meaningless without any scale

Revision Suggestion : Add scale

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 210
Paragraph : Subsection Floor Truss and Slab Damage, second paragraph
Comment : Part of the requirements of the original solicitation was to examine the stability of two towers after losing the columns and show that the towers stood up after the event (Page 10 of SB1341-03-Q-0334).
Comment Reason : See also our previous comments concerning natural frequency, we do believe the method used takes account of possible damage that may occur during the post impact sway and therefore subsequent stability.

Revision Suggestion : Re-assess to take account of any damage resulting from post impact sway response.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 218
Paragraph : Paragraphs 3 and 4
Comment : What technical validation has been done regarding the modelling of fuel dispersion?
Comment Reason : We recognise that the fuel dispersal simulation is technically challenging. It is therefore sensible to undertake some validations using simple experiments before embarking on a complex study such as this.

Revision Suggestion : Clarify what level of confidence there is in the fuel dispersion work?

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 234
Paragraph : Figure 9-29
Comment : Figure 9-29 b) identifies debris at time=0.715s. Page 227 states that this model only ran to 0.62s.

Also a scale on diagram b) might be useful.

Comment Reason : We think the time note on diagram b) is erroneous

Revision Suggestion : Modify time and add scale

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 343
Paragraph : Second paragraph
Comment : Very little information about debris found beyond the vicinity of the towers seems to have been made available to NIST. For example, the size of panel and mass of landing gear shown in figure 9-123 is unknown. How could this collection of this data following a tragedy be improved?
Comment Reason : Improved process for data collection of debris needed.

Revision Suggestion : It would be useful to make sure some comment about debris collection/recording is put in findings.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 361
Paragraph : Section 9.11.3 Comparison with Observables Paragraph 2
Comment : Recognising that the overall trajectories are a difficult thing to predict, the trajectories of components as they left the building were poorly predicted in the simulations. As this is critical to establishing the damage to the core it would have been useful to discuss the reasons for this in more detail.
Comment Reason : Critical to establishing the core damage key objective

Revision Suggestion : Discussion concerning the reasons for poor correlation of analysis with observables.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : v
Paragraph : Paragraph 2 last sentence
Comment : The SPH approach used by ARA in the analysis for the fuel dispersion following the impact is relatively untried and is not well validated through experiments. Could the researchers clarify what level of confidence they have in the accuracy of predicting fuel dispersion and how this might have influenced the subsequent fire analysis?
Arup□s experience in the modelling fluids suggests fuel dispersion an exceedingly difficult thing to predict and an area where any analysis needs to be considered carefully and supported by laboratory based experimental validation. Given the importance of this study, we believe some testing should have been carried out to confirm the analytical models used prior to assuming dispersal patterns are adequate or correct.

Comment Reason : The report does not adequately explain the limitations of the technical approach taken.

Revision Suggestion : Clarification of the level of confidence or uncertainty in these results.

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From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : x1vi
Paragraph : E.2.1 Global Models of Towers
Comment : Was any attempt made to correlate the total weight of the building with the debris removed?
Comment Reason : While accepting that this would have been an approximation, the data could have been used to estimate the overall loads on the building at the time of impact. This would have given greater confidence in the levels of reserve available at the time of the impact.

Revision Suggestion : Compare amount of debris known to have been removed during the clear operation with the mass used in the global analysis models.

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1iv and 1v
Paragraph : Demand Capacity Ratios (DCRs) Paragraph 2
Comment : The baseline analysis examines the DCRs for design loads on the complete tower (figures E-5 and E6). Given that the actual building would typically see less load than this, has any estimate of the actual DCRs for the building in its Sept 11 2001 states? Given that the corners, which general had DCRs in excess of 1, were shown to buckle during the building collapses it might be useful quantify the reserve capacity in the column by checking the DCRs for actual loads on the day for pre and (immediately) post impact states and check these were less than unity.
Comment Reason : Looking a actual DCR□s would provide better estimate of the condition of the building post impact, a main objective of project 2.

Revision Suggestion : Re- analyse using actual loads

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1viii
Paragraph : Section E.5.1 Development of Tower Impact Models
Comment : We believe the global model (of the type shown in figure E-11) had no initial stress in the column and that this was justified by some simple tests using column models. The global model also ignored the overall response of the structure, presumably on the basis that the duration of the impact event was significantly less than the natural period of the building. Could NIST clarify how any P-Δ effects (as a result of the swaying) in the post impact condition were accounted for? From the work reported, post impact P-Δ effects before the fire took hold seem to have been neglected but there is no justification is given. Could P-Δ effects as a result of the significant swaying of the building after impact have influenced the severity of the column damage?
Comment Reason : Inadequancy in the analysis

Revision Suggestion : Justification for neglecting this or re-analysis taking load re-distribution and P-Δ effects into account.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xv
Paragraph : Section E.5.2 Development of Aircraft Impact Models, Paragraph 1
Comment : The report is vague as to exact details of the aircraft data used □ much of the aircraft model seems to have been developed without detailed engineering drawings or more than some cursory measurements. Whilst it might be argued that the strength of the fuselage is not that significant, the 1-2B report (page 368, section 10.2, last paragraph) notes, and we agree, that the strength of some of the denser elements are significant. Recognising Boeing□s desire to retain proprietary information, have Boeing engineers scrutinised the component masses, thicknesses and dimensions used in these models? Have other LS-Dyna experts checked the aircraft impact model in the same way that SOM checked the building models?
Comment Reason : The limited data used to develop the aircraft models may not have been adequately bounded by the uncertainty analysis. Given that the structure of a B767 aircraft is known it seems sensible to check this data where possible.

Revision Suggestion : Clarification regarding the level of checking used in developing the aircraft data.

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Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxviii
Paragraph : Section E7.1 WTC1 Base Case Analysis, Paragraph 2
Comment : As noted previously (see comments on pg lxv) the aircraft models appears to be based on relatively sparse engineering data □ this is surprising, given that B767 design data exists and any inaccuracies in the aircraft model would increase the level of uncertainty in the result. Our concern relates to the limited details in the report about the undercarriage structure and assembly and wing supports (typical weighing 10-12tons)?
Comment Reason : These would have been critical elements determining the state of the core.

Revision Suggestion : Clarify what detailed information was used to model this component and how was this data collected?

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Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxixx
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section External Wall Damage, Paragraph 2
Comment : How were gravity and aero-elastic forces on the wing applied? It seems the wing deflections in flight were accounted for but the report if unclear how this was done?
Comment Reason : Limited information in report

Revision Suggestion : Clarification

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxxv
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 1,
Comment : Limited experimental validation work that has been carried out using this method for fuel dispersion. As the analysis ignored the containing effect of the windows, wetting and the multi phase nature of the fuel combustion process during impact, the actual results are at best subjective.
Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : ci
Paragraph : E.7.2 WTC2 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 2,
Comment : See previous comments on (pg lxxxv above) regarding the use of SPH to model fuel dispersal.
(The report notes that the work could not reconcile the fuel getting through 200/300 sides.)

Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : cix
Paragraph : Section E.7.7
Comment : Detailed comparison of damage on □back□ walls (ie south wall of WTC1 and north face of WTC2) between observables and analysis are not shown. The reports notes later that correlation between the impacts and analyses are poor on these faces.
Comment Reason : Limited information in report

Revision Suggestion : Clarification of impact damage estimates

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From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 6
Paragraph : Section 1.3 Aircraft Impact Damage Analysis Bullet 2
Comment : The sensitivity analysis seems to neglect much of the uncertainty in the aircraft data used in the model. (see our previous comments relating to Page lxxvii)
Comment Reason :

Revision Suggestion :

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 93
Paragraph : Section5.1 Introduction
Comment : We have often found in large civil and building engineering models, used to explicitly simulate impact and seismic events in real time, variation of results between LS-Dyna analyses using 32 bit and the higher precision 64 bit software. We have occasionally seen significant rounding errors on 32 bit computer software when representing physically large dimensions where relatively small displacements in elements trigger failures. Were any of the results models checked using 64 bit precision to test the accuracy of results? The limitations on models size noted in the report are related to 32 bit operating systems. If the impact models had been run on 64 bit operating systems we believe the limitations on model size would have been avoided.

Comment Reason : One dimensionally large model the accuracy of the analysis results needs to be checked using double precision.
The original NIST objective of using state of the art analyses for the Project 2 seems to have been missed. The limitation on model size could have been avoided by using computers with 64 bit operating systems.

Revision Suggestion : Re-analysis of a few of the larger models using 64 bit software.

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Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 269
Paragraph : Section 7.10.1 , Comparison with Observables on WTC1 Landing gear Trajectory
Comment : We accept that the trajectory calculations are difficult. Our calculations show this to be 120mph if no rolling occurred. Was there any evidence of rolling or ricocheting down the road?
Comment Reason : Limited information concerning the observables

Revision Suggestion : Comments regarding the processes used for recording debris data.

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From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 281
Paragraph : Section 7.10.2, Comparison with Observables on WTC2, Engine Trajectory Comparison
Comment : Could the crash investigators tell whether this was a starboard or port engine?
Comment Reason : Limited information

Revision Suggestion : Clarifcation

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From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 289
Paragraph : Section 7.11.1 Comparison of External Wall Damage
Comment : See our previous comments about the modelling of fuel in the impact. Was any sensitivity study carried out using the SPHs to correlate this with fuel falling out of the building?
Comment Reason : Shortcoming in SPH method

Revision Suggestion : Clarification of limitations

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From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 11
Comment : Although conventional office buildings tend not to consider aircraft impact as a foreseeable hazard, nuclear facilities in the US and elsewhere do. The finding that an aircraft impact was considered at the time of the design of the WTC1 and 2 demonstrates that the possibility of impacts whether accidental or deliberate may need to be considered in some circumstances. Although current building codes don□t consider aircraft impact, it seems reasonable to assume that tall buildings or iconic architecture can be considered targets. The work carried out here should be developed to provide useful information to assist those wishing to design more robust buildings and other facilities irrespective of the building codes.
Comment Reason : General observation

Revision Suggestion : None

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 13
Comment : While generally in agreement that this could be the case, the SPH methodology used should be properly validated. Whether or not this has been done as part of this investigation is unclear.
Comment Reason : There is limited information in the reports to support this finding

Revision Suggestion : Clarification

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From: j <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : j
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 300
Paragraph : Finding 18
Comment : The implication that the tower had sufficient reserve capacity because the natural frequency of the buildings post impact was similar to the undamaged state is incorrect. Because the construction of the towers is essentially tube like, the natural frequencies would not alter significantly even if the core was severely damaged. The following simple FE models demonstrate the insignificance of the core:
Simplistic Model Results

Results from five simple finite element models (of roughly the same geometric proportions as WTC1 and WTC2) demonstrate that a large hole in the side of a tube and the missing parts of the core do not significantly influence the natural frequency (see table 1).

Table 1 Variation of Natural Frequency (in Hz)

	Model 1	2	3	4	5
Bending	0.1653	0.1647	0.1643	0.1636	0.1637
Torsion	0.5981	0.5889	0.5981	0.5891	0.5889

Model 1

Tube & core
No holes Model 2

Large hole in side & no core. Model 3

No hole with core Model 4.

Large hole in side with core Model 5

Large hole in side and core missing at same level

Comment Reason : The stability of the towers immediately following the impact has not really been proven by the impact analysis. Simply taking the results of the impact damaged structure and loading it statically effectively ignores and damage that may have resulted due to swaying.

Revision Suggestion : Provide a more detailed analysis to take account of load path re-distribution in the core and the P-Δ effects of sway following the impact.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005